MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2015/2016

TIF 2721/TSE 2351 – INTRODUCTION TO FORMAL METHODS

(All sections / Groups)

13 OCTOBER 2015
2.30 – 4.30 p.m
(2 hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages with 5 Questions only, excluding the cover page.
2. Attempt **FOUR** out of **FIVE** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1 (4 + 3 + 3 marks)

a. Decide if the following are true or false. Explain your answers:

i. $\{1\} \in \{4, 3, 2, 1\}$

ii. $\emptyset \in \mathbb{P}\{1, 2, 3\}$

iii. $\forall S, T: \mathbb{P}\,\mathbb{N} \bullet (S \subseteq T) \vee (T \subseteq S)$ (S and T are sets of natural numbers)

iv. $\forall x: \mathbb{N} \bullet \exists y: \mathbb{N} \bullet x + y^2 > x^2 + y$

b. Give two reasons why formal specification provides a good representation in software engineering.

c. Let *father* and *mother* be relations of type *Person* $\leftrightarrow$ *Person*. Furthermore, $x \mapsto y \in$ *father* iff y is the father of x and $x \mapsto y \in$ *mother* iff y is the mother of x.

Define the relation *grandmother* in terms of *father* and *mother*. You may use variables and quantifiers.

Continued .....

Question 2 (4 + 4 + 2 marks)

a. The relations R and S are defined by:

$$R == \{ 1 \mapsto 2, \; 2 \mapsto 3, \; 3 \mapsto 2, \; 3 \mapsto 3, \; 4 \mapsto 1 \}$$

$$S == \{ 1 \mapsto 2, \; 2 \mapsto 3, \; 3 \mapsto 4 \}$$

Write each of the following sets in extension (relational composition):

i. $R \; ; S$

ii. $S \; ; R$

b. You are given two Z schemas A and B as defined below. Construct $A \gg B$. Show all the necessary steps.

$$A \triangleq [\; c, y?, s', x! : \mathbb{N} \mid s' = y? + x! \; ; \; c < x! \;]$$

$$B \triangleq [\; n', x?, s, x! : \mathbb{N} \mid s = n' - x? ; \; n' = x! \;]$$

c. An organization plans to formally specify the staff personal details. There are two possibilities to relate a staff to his/her telephone number.

Option 1: *phoneNum*: PERSON → PHONE

Option 2: *phoneNum*: PERSON ↔ PHONE

Explain the difference between Option 1 and Option 2. When is Option 1 useful?

Continued .....

Question 3 (3 + 4 + 3 marks)

Let [*People*] be the set of all possible persons and [*Subjects*] the set of all possible subjects. A specification for a *University* has the following state schema:

University

$students : \mathbb{P}\ People$
$subjects : \mathbb{P}\ Subjects$
$enrolments : People \leftrightarrow Subjects$

$\text{dom}\ enrolments \subseteq students$
$\text{ran}\ enrolments \subseteq subjects$

Specify the following operations:

a. An operation schema *newStudent*, such that a person (*pers?*) is enrolled as a student.

b. An operation schema *newEnroll*, such that a student (*pers?*) enrolls into a subject (*subj?*).

c. An operation schema *personSubjects*, which outputs the set of subjects (*subjs!*) in which the person (*pers?*) is enrolled.

Continued .....

Question 4 (3 + 5 + 2 marks)

a. Two bags, R and S are defined as follows:

$$R = \{toyota \mapsto 8, proton \mapsto 3, honda \mapsto 12, nissan \mapsto 11\}$$

$$S = \{proton \mapsto 15, nissan \mapsto 4, ford \mapsto 6\}$$

Find the following:

i. $R \uplus S$

ii. $S \sqcap R$

iii. $R \sqcup S$

b. Specify a function (in Z notation) that takes as input a sequence of natural numbers and returns the **product** of the odd numbers.

c. Describe the role of the Floyd-Hoare logic in the context of formal specification.

Continued .....

Question 5 (3 + 3 + 4 marks)

a. Given a Hoare triple below:

$\{x = 5\}\ x := (x * 2) + 7\ \{x > 5\ \&\&\ x < 20\}$

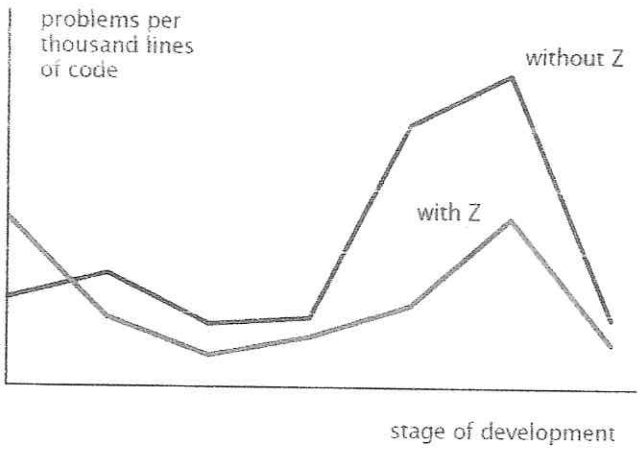
i. What is the pre-condition?

ii. What is the post-condition?

iii. Briefly explain why the post-condition is a weak post-condition. What is the strongest post-condition?

b. Briefly describe 3 applications which will greatly benefit when formal specification is applied in the development of a system. Explain how each application can benefit from formal specification.

c. The graph below clearly shows that the implementation of formal specification significantly reduces coding problems in the development of the system.



Explain why some software developers are still reluctant in applying formal specification in their system development.

End of Page